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Is vegetarianism bad for the environment?

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ABSTRACT

Search the internet using "vegetarianism and environment" and you will find several articles by prominent people espousing the view that vegetarianism is bad for the environment. One of the recent articles on the subject by Professor Mike Archer entitled "Ordering the vegetarian meal? There's more animal blood on your hands" attracted a lot of comment when it appeared in the Conversation in 2011. Archer, in his article, argued that "if you want to minimise animal suffering and promote more sustainable agriculture, adopting a vegetarian diet might be the worst possible thing you could do." He claims that if we stop eating grazing animals and turn to a vegetarian diet then we will need to farm an additional area the size of Victoria plus Tasmania to meet our nutritional needs. Compared to rangeland grazing, clearing such large areas for crops means a loss of the vegetation and many of the resident animals. The livestock industries must relish this free promotion. But, the logic is wrong – dangerously wrong! After providing a brief history of the Australian diet, food industry and animal industries, I point out, with some simple calculations, that as appealing as the argument may sound it has no basis. Instead, lacto-ovo vegetarians need to ingest about 30 kg of protein from crops in a year, which includes 10 kg fed to dairy cattle and laying hens. In contrast, before they eat any vegetable matter the average Australian omnivore will have indirectly consumed a staggering 38 kg of plant protein, just in the chicken and pig meat they eat. This increases to 48 kg of protein when we include eggs and dairy products. This should not surprise anyone with a rudimentary knowledge of ecology, who would know that eating at higher trophic levels elicits a loss of nutrients. The last thing we need is prominent people promoting dangerous agriculture with more land clearing and further decimation of native flora and fauna. Instead, a largely vegetarian diet makes environmental sense while also offering health benefits. I finish by elaborating on some of these issues.

Key words: lacto-ovo vegetarian, omnivore, protein, requirement, amino acid, soybean

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It seems intuitive that ideas are far more dangerous when they emanate from those in positions of authority and influence in public discourse – public intellectuals. People attain these positions through intense inquisition and thus become experts in their field. But anyone who has become knowledgeable in any subject will acknowledge that stepping away from that discipline into even a partially related one should engender a series of doubts that one conquers only by more research. After battling another treadmill to acquire knowledge in a new area, the person can add another discipline to their expertise. Now what happens if that person expresses an opinion on a particular topic outside of their expertise without doing the necessary research? I hope those who suggest that vegetarianism is bad for the environment have stumbled into this trap. The alternative is that those targeting vegetarians have opted to selectively mine the data to support their point of view.

So, vegetarianism is bad for the environment! It is obvious isn't it? If people refrain from eating meat and turn to a vegan existence, where they shun all animal products or a vegetarian one where they may consume some foods sourced from animals, such as eggs and dairy products, then we will need to grow more crops on our dry and nutrient impoverished continent or import them. Assuming we grow these crops in a modern agricultural system – vast monocultures, this will require clearing more land, using more agricultural chemicals and water and, in the process, inadvertently killing more animals and further damaging the environment. In the remainder of this article, I will dissect the facets of the case for Australia – what meat we eat, its origins, the resources used to produce it and our requirements for protein, to show that those targeting vegetarians have misunderstood the origins of our food and have thus chosen the wrong target. The appropriate target is not those who lead a largely vegetarian existence but instead an average Australian omnivore. Incidentally, I am going to argue the point from the stance of the lacto-ovo vegetarian because, relative to the vegan diet, it makes the point simpler. To elaborate, both meat eaters and lacto-ovo vegetarians eat eggs and dairy products so if we assume that the two groups eat similar amounts of these products then we can largely ignore them in calculations.

A chain of events

The mere mention of words like "vegetarian" and "vegan" opens the floodgates of viewpoints, often from those justifying their particular lifestyle. There are also many books on the pros and cons of a vegetarian diet and agricultural efficiency but two recent examples deserve mention – Lierre Keith's "The vegetarian myth: food, justice, and sustainability" (Keith 2009) and Simon Fairlie's "Meat: a benign extravagance" (Fairlie 2010). In contrast to Keith's book, which displays poor research and a misunderstanding of basic nutritional principles, Fairlie's well-researched and well-argued tome examines whether vegan agriculture is sustainable or even sensible. He concludes that it is not sensible, largely because animals are such an important part of agriculture. Foregut fermenting animals, such as cattle, sheep and kangaroos, can flourish on pasture thus turning a substance that humans cannot eat into animal protein – meat and milk and more animals. Pigs, on the other hand are marvelous converters of waste – food scraps and the like. Of course, all of these animals are efficient fertilisers of the land and what better way to fertilise the land than with an animal rather than a machine burning fossil fuels as it spreads fertilizer derived from them?

Various writers have responded to these books including George Monbiot, an environmental and political activist, author and journalist. In fact, Fairlie's book had such a profound influence on Monbiot that in his article in the Guardian (Monbiot 2011) he describes tossing in his vegan lifestyle for one of limited meat, while emphasizing the need to farm it properly.

Writing in The Conversation and in Australian Zoologist, the prominent Australian biologist, Professor Mike Archer (2011a,b) cites all of the above – Fairlie (2010), Keith (2009) and Monbiot (2011) to justify his argument that there will be more blood on your hands should you choose the vegetarian meal. He states his thesis clearly in an opening paragraph "The ethics of eating red meat have been grilled recently by critics who question its consequences for environmental health and animal welfare. But if you want to minimise animal suffering and promote more sustainable agriculture, adopting a vegetarian diet might be the worst possible thing you could do." He continues to argue that vegetarianism is bad for the environment with statements like "Most of Australia's arable land is already in use. If more Australians want their nutritional needs to be met by plants, our arable land will need to be even more intensely farmed. This will require a net increase in the use of fertilisers, herbicides, pesticides and other threats to biodiversity and environmental health. Or, if existing laws are changed, more native vegetation could be cleared for agriculture (an area the size of Victoria plus Tasmania would be needed to produce the additional amount of plant-based food required)."

The trouble with Archer's argument is that he has fallen into the trap of either inadequately researching the subject or selectively mining the data to support his viewpoint. The evidence for the inadequate research is that he does not provide any information on what the average Australian eats and the origins of that food. The selective use of the data comes about because he chooses to compare a meal of red meat with a generic vegetarian meal. So, what do Australians eat?

A brief history of Australian food

Human remains suggest that Aboriginal peoples occupied the Australian mainland for at least 45,000 years before the arrival of the European settlers in 1788, having descended directly from the first humans to leave Africa 50,000-70,000 years ago (Hudjashov et al. 2007). By then between 300,000 (Smith 1980) and 750,000 (Mulvaney and White 1987) indigenous people inhabited all parts of Australia from the rich coastal environments to the driest parts of the inland, having grown in population in the previous 5,000 years (Johnson and Brook 2011). They were semi-nomadic peoples existing on a diet of vegetables, grains, fruits, animals and fish while prizing the larger marsupials and other game that was uncommon or elusive (Lourandos 1997).

This all changed with the arrival or, in the eyes of aboriginal people, the invasion of Australia by Europeans. No longer did the inhabitants of Australia live as hunter-gatherers but instead there was a growing dependency on imported foods – typically the foods of Britain's urban underclass: meat, milk, potatoes, bread, tea and sugar. These foods nourished the fledgling nation and provided the staples for the next 150 years. The reliance on imported foods, however, did not last long. After a stumbling start, agriculture flourished (Farrer 2005).

Two key circumstances influenced the Australian diet. The first was the opening of the interior and the expansion of the sheep industry. A ready market for Australian wool in Europe meant a typical surplus of sheep meat. As noted by Symons (2007), this 'grazing success turned us into a nation of meat eaters' to the point that meat was an important component of the rations paid weekly to the workforce. The second key circumstance was the invention of refrigerated shipping, thanks largely to the inventive genius of Sydney resident Eugene Nicolle that allowed those in Britain to enjoy frozen rather than salted Australian meat for the first time in 1880 (Farrer 2005). This further boosted the production of meat.

This simple meat-based diet endured through the 1960's but since then the Australian diet – at least the diet eaten by urban dwellers, has changed rapidly. Gone, fortunately, are the days of a slab of red meat sitting beside three boiled vegetables. Unfortunately, also in decline is the home-cooked meal. How and why did these changes occur? As Symons (2007), points out, there is probably no simple explanation.

Instead a combination of factors, such as the arrival of the supermarkets, migration, television advertising, a higher proportion of women in the workforce, fragmented meal times, an increase in "convenience foods", declining food prices and health messages targeting saturated fat and cholesterol, all interacted to change our society and our diet.

Among these, supermarkets and convenience foods deserve brief mention. In Australia, two large companies – Woolworths and Coles, dominate the grocery industry and supply an ever-increasing number of food items in each store: 1,500 in 1950, 8,000 in 1970, 12,000 in 1975 (Symons 2007) and 55,000 in 2010 (FSANZ 2011). Many of these new foods are frozen convenience foods that come from large food corporations with sophisticated production methods backed by food scientists, marketing personnel and burgeoning budgets for advertising. The combination of demographic trends, such as more ethnic diversity, more dual-income households and declining fertility rates, influenced affluence. This resulted in Australians eating more meals outside the home (Symons 2007). Details from the Australian Institute of Health and Welfare indicate that while households spent around one-fifth of their weekly food budget on eating out in 1984, today that figure is about one-third. The same report also said that restaurant and takeaway meals was the single item on which Australian households in all income brackets spent most of their food budget ($63 per week or 27% of household food expenditure in 2009-2010) (AIHW 2012). In turn, the number and variety of restaurants increased and a wide range of cuisines began to influence Australian eating patterns. But prominent among the meals eaten out of the home are those from fast food chains. By 2007 about 17,000 outlets sold more than 1.64 billion meals and takeaways per year – about 80 for every member of the Australian population (BIS Shrapnel 2009). While the global financial crisis hit restaurants and cafes it did nothing to reduce our spending on takeaway food – $37 billion in 2011. Most of this went to the 1250 Subways, 845 Domino's, 780 McDonald's, 300 Hungry Jacks and 500 KFCs (BIS Shrapnel 2011).

As we might expect, our increased consumption of convenience foods has spawned another, albeit much smaller movement – ethical consumerism. Ethical consumers base their purchases on their personal beliefs. Thus, from a dietary perspective they may select foods that minimize harm to or exploitation of the environment, animals or, increasingly, other humans – Fairtrade coffee being a good example. Conversely, ethical consumers boycott foods that they associate with exploitation (Heij 2005). It should come as no surprise that there is a close link between ethical consumerism and vegetarianism.

Vegetarianism

Vegetarian diets are those based on foods from plants, such as grains, vegetables, nuts and fruits, to the exclusion of meat products. A variety of terms describes vegetarian diets. For example, "pescetarians" eat a largely vegetarian diet supplemented with fish and other seafood, while semi-vegetarians refrain from eating red meat only. At the opposite end of the spectrum lie vegans, who consume no food of animal origin, and often refuse to use animal products, such as leather or even honey. There are many reasons for adopting a vegetarian lifestyle of which the three main ones are environmental, health and ethical concerns. Environmental concerns include the destruction of forests and planting of pastures for grazing animals, the contamination of waterways by animals, methane production by ruminants and the focus of this article – the vast waste associated with feeding crops to livestock. Among the three reasons, vegetarians often cite animal welfare issues – intensive housing of animals, transport of animals and their mass killing in abattoirs, as the philosophical motivation for their food choices (Lea and Worsley 2003).

There are limited data on vegetarianism in Australia. The self-reported prevalence of vegetarianism among Australians aged 19 and over was 3.7% in 1995, as reported by the National Nutrition Survey. Vegetarianism was more common among women and younger people (ABS 1997). A random survey of 1,202 Australian adults conducted by Newspoll in 2009 found that 5% of respondents reported they were vegetarian and 1% vegan. Based on the foods they reported eating, however, only 2% actually ate a vegetarian diet, and only 0.6% a vegan diet (Vegetarian and Vegan Society of Queensland 2010). The problem with this form of questioning is that it overlooks those who are largely vegetarian. Perhaps a better approach is to ascertain how many vegetarian meals Australians consume each week. Reid et al. (2012) did this and determined that seven out of ten Australians are eating more plant-based meals than they did previously. This tends to agree with the latest findings from Roy Morgan Research (N = 20,272) that 10% of Australians aged 14 and over agree with the statement 'The food I eat is all, or almost all, vegetarian' (Roy Morgan Research 2013).

Changes in agricultural practices

Changes in food habits coincided with vast upheaval in the agricultural industries. The 20th century saw Australian agriculture move away from the traditional mixed farm, orchard or market garden towards more intensive agriculture. Invariably, farm numbers dropped and their size increased along with parallel increases in the degree of mechanisation and the use of chemicals (Henzell 2007). This change was perhaps most evident in the intensive animal industries.

The intensification of the poultry and pig industries

Closely linked to the rise of the "convenience foods" industry was the advent and escalation of the intensive poultry industries. In 1950 Australian chicken farmers produced about 3 million meat type chickens per year (less than half a bird per person per year) using "dual purpose" strains whereby farmers raised females to produce eggs and males for meat. All this changed with intensification of the poultry industries in the late 1950's. The production of 'dual purpose' chickens for eggs and meat ceased and the industries went their separate ways, with the breeding of poultry strains for eggs (layers) or for meat (broilers). Changes occurred quickly, both in the number of chickens raised and in their growth rates. While Australians steadily ate more chicken throughout the 1960's, they took a particular liking to it when Kentucky Fried Chicken reached our shores in 1968. By the early 1970s Kentucky Fried Chicken was opening up to 75 stores a year in Australia and the Australian broiler industry responded by increasing production by 38%. Now, forty years later, a handful of companies produce most of the 600 million broiler chickens slaughtered annually in Australia (about 27 birds per person per year) (Australian Chicken Meat Federation Inc. 2011). A substantial number of these chickens end up in the takeaway food industry. For example, the KFC website states:

> *"Today KFC serves 2 million customers every week (that's a lot of chicken) through over 600 stores across Australia. This makes KFC one of the largest fast food chains in the country." (KFC Australia 2014)*

While it took about 90 days to raise a broiler chicken to 2 kg live-weight in 1960, it now takes fewer than 35 days, with the change almost wholly attributable to genetic selection (Havenstein et al. 1994; Havenstein et al. 2003). Due to their fast growth rates, each generation of these chickens required less food to reach a set body mass. They do this, however, by eating high protein diets (20-23% of dry matter) formulated mainly from grains and protein concentrates derived from oilseeds, such as soybeans (NRC 1994). These are all ingredients that humans can eat with little processing. Also, today chickens live in modern animal houses with closely controlled climate – temperature, humidity and ventilation.

Like the poultry industries, the Australian pig industry also evolved from a sideline enterprise to an industry in its own right. As pointed out earlier, pigs are marvelous converters of wastes and byproducts. In Australia, one of these was skim milk, a by-product of a dairy industry that supplied cream to butter and cheese factories. In areas close to these factories, pig farmers could use the whey and thus obtain a cheap source of high quality protein. In Victoria some of these factories had their own piggeries (Cutler and Holyoake 2007). It was common too for Australian grain farmers to raise a few pigs to make use of second-grade crops.

Changes to the dairying industry led to changes in the pig industry and from about 1970 it changed quickly from a sideline industry to the intensive industry that exists today (Australian Pork 2011). Those that could apply new technologies succeeded at the expense of those with poorer management or a lack of resources. Between 1960 and 2005, about 90% of the original 50,000 producers left the industry while pig numbers remained roughly constant. The average number of sows on a property grew from about 4 to 325 (Cutler and Holyoake 2007; Dowling 2006), the latter housed indoors and fed on diets comprising predominantly grains and plant protein concentrates – again, perfect foods for humans. In contrast, these pigs eat none of Australia's food waste on which they could thrive – a point I discuss later.

The Australian grazing industries

Since Archer (2011a,b) focuses his argument on the consumption of red meat I will provide a brief description of Australia's grazing industries.

Australia is a continent populated with domesticated ruminants – predominantly cattle (28.5 million) and sheep (74.7 million) (Meat and Livestock Corporation (MLA) 2012-2013). We tend not to eat these animals and instead export them. In 2012-13, Australia exported 51% of lamb and nearly all mutton and 67% of the beef it produced (MLA 2012-13). Maps of the distributions of these grazing animals on the MLA website show that while sheep occur in low numbers over much of Australia with the exception of northern regions, most occur in New South Wales, Victoria and the southwest of Western Australia. Cattle also occur over most of the country but, in contrast to sheep, graze mainly in the rangelands of Queensland and the Northern Territory. Expressed in broader terms, the Australian Government's Department of the Environment, Water, Heritage and the Arts (2008) report that about 60% of Australia's area produces livestock. The State of the Environment Committee (2011) (SEWPAC) calculated that 46% of Australia's land area is native pastures used for grazing – that is, Australia's rangelands. The area of modified pasture (9% of Australia's area) is also significant because it is triple that used for dryland cropping (SEWPAC 2011) and obviously requires the removal of vegetation. As also noted in SEWPAC (2011), the clearing of many plant communities now considered to be endangered under both state and federal legislation occurred for a combination of both cropping and grazing. For example, Brigalow as listed under NSW, Queensland and Commonwealth legislation was historically cleared for both grazing and cropping uses. The yellow boxred gum woodlands of the NSW and ACT tablelands provide another example. The current threats to this community are noted by SEWPAC as "continued tree clearing, high total grazing pressure and proliferation of exotic species".

The rangelands provide a similar picture of degradation by introduced grazing animals. Until recently, one could only imagine the environmental damage caused by this activity but studies at "Mornington" in the central Kimberley in the north of Western Australia show that mammalian fauna recovered quickly following the removal of introduced herbivores – mainly cattle (Legge *et al.* 2011). Thus, SEWPAC (2011) conclude that extensive beef production causes the clearing of native vegetation, altered fire regimes, altered hydrology, trampling and compaction and facilitates the introduction of invasive species. Grazing, even at low animal densities, is an activity that greatly alters the landscape.

What animal products do Australians eat?

In 2010 an average Australian ate 118 kg of animal meat from the major sources. This included 44.8 kg of chicken meat, 35.7 kg of beef and veal, 24.8 kg of pig meat and 11.3 kg of lamb and mutton (FSANZ 2011). On top of this, Australia produced 357 million dozen eggs of which 122 million dozen were sold as whole eggs through retail outlets (Egg Marketing Board 2013). Of course, to this list we can add minor amounts of other meats – poultry (e.g., turkeys, geese and ducks), goats, kangaroos, buffalo, crocodile, etc, and also seafood of which we each eat 15 kg per year. In this article I ignore all of these minor animal products. We can divide the main animal products into two categories – those produced from animals eating pastures and those from animals eating crops that humans could eat. For the sake of simplicity I have taken a conservative approach and assumed that all beef cattle and sheep eat only pasture and that farmers feed poultry and pigs only on crops. The latter is essentially true whereas there is a growing tendency to "finish" beef cattle in feedlots where they eat substantial amounts of grain. I have also ignored minor items such as the 6 million great grandparent, grandparent and parent broilers chickens – the ancestors of the chickens we eat.

Dairy cows present a special case. About 98% of Australian dairy cows eat mainly pasture while 2% do not graze at all – feedlot animals (SEWPAC 2011). Nevertheless the grazing animals typically receive a nutritional supplement and thus consume large amounts of crops, the amount depending on issues such as location, season and stage of lactation. I estimate the amount of crops they eat in Table 1. However, as I pointed out earlier, to more simply tackle the question of whether vegetarianism is worse for the environment I compare an Australian omnivore with a lacto-ovo vegetarian. Then, by assuming that an average person from each of these groups consumes similar amounts of dairy products and eggs, I can largely ignore these animal products in further calculations. This means that I can

Table 1. The consumption of animal products by Australians and details of the crops required to produce the animal products.

Product	Consumption kg/person/yr	Grass or crop	Feed conversion ratio	Crops fed to animals (kg/person/yr)	Crop protein fed to animals (kg/person/yr) [5]
Chicken meat	44.8	Crops	2.4 [1]	97	19.4
Pig meat	24.8	Crops	4.75 [2]	106	19.0
Eggs	11 [3]	Crops	1.5 [4]	16	3
Milk products	325	Pasture and Crops	N/A	60	7
Beef and veal	35.7	Pasture	N/A	0	
Lamb and mutton	12.2	Pasture	N/A	0	
Total	**454**			**279**	**48**
Total excluding eggs and dairy	**118**			**203**	**38**

[1] – Chicken FCR: calculated from an FCR of 1.7 (whole bird) and assumes a dressed weight of 70% of which all is eaten. Ignores great grandparent, grandparent and parent flocks numbering six million (e.g., Australian Chicken Meat Federation Inc. 2011; Aviagen 2014)

[2] – Pig FCR: whole herd dressed weight is 3.8 but 20% of dressed weight is waste.

[3] – Eggs: Calculated as 213 eggs*60 g – 11% shell egg (Egg Marketing Board 2013)

[4] – Egg FCR = kg food per dozen eggs (ignores 10 kg of food required to get the chicken to the point of lay)

[5] – Assume protein contents of diets (% dry matter) of 20% (chicken), 18% (pig) and 18% (eggs). I assume that the diets contain 10% meat meal that contributes 5% dry matter protein. In other words, 25% of the protein in the chicken diet comes from meat meal.

Table 2. The recommended dietary intake (RDI) for protein of Australian adults and the consumption of protein by Australians eating an average diet and by vegetarians.

	Males	Females	Combined genders	Vegetarian combined genders[1]
RDI protein (g per day)	64	45	54.5	54.5
RDI protein (kg per year)	23.4	16.4	19.9	19.9
Protein intake (g per day)	111	92	102	67
Protein intake (kg per year)	40.3	33.3	36.8	24.5

[1] – calculated from males aged 20 to 50 years eating a lacto-ovo vegetarian diet and females aged 18-45 eating either a lacto-ovo vegetarian diet or a vegan diet (Marsh et al. 2012).

also ignore the food eaten by the ancestors of our laying-strain chickens and the 10 kg of feed required to get a laying chickens to the point when it lays its first egg.

There is one necessary qualification: the feeding of meat meal and meat and bone meal to poultry and pigs, both of which are legal practices. These ingredients supply large amounts of protein and thus substitute for plant protein in the diets of the intensively farmed animals. They also supply appreciable amounts of phosphorus and calcium, which plant products cannot do. In Table 1 I assume that all diets fed to poultry and pigs contain 10% meat meal, which supplies a quarter to a third of the dietary protein.

Table 1 shows that our consumption of chicken and pig meat requires farmers to grow about 200 kg of crops per person per year to feed the animals that we slaughter for their meat. As I point out, these crops are typically cereals (wheat, maize, barley, triticale, etc) and oilseeds (soybeans, sunflowers, canola, etc) that with little processing can supply the nutritional needs of humans (eg Australian Chicken Meat Federation Inc. (2011; Australian Pork 2011). In order to compare the crops indirectly eaten by those consuming meat, with the amounts needed if we were all eating a lacto-ovo vegetarian diet, we need a common currency. In this case I use protein because animal products, like oilseeds, supply large amounts of protein to our diets. In other words, they are interchangeable sources of amino acids – the nutrients that protein supplies.

The National Health and Medical Research Council recommends that Australian men and women (14-70 years) eat 64 and 45 g of protein a day, respectively (National Heath and Medical Research Council 2006). Thus, the annual requirement for protein is 23.4 kg for men and 16.4 kg for women or a population average of 19.9 kg. We do not have a requirement for protein as such but instead we require nine essential amino acids – substances that our bodies cannot make, and enough non-essential amino acids for the synthesis and repair of all body protein – muscles, enzymes, hormones, blood cells, keratin and so forth. The average Australian actually eats much more protein than the recommended amount, with the averages for Australian males and females (10 years and above) of 111 and 92 g of protein per day, respectively (Table 2). Thus, an average Australian consumes 36.8 kg of protein per year, while vegetarians eat rather less protein and not much more than the recommended dietary intakes.

Let us now compare these average figures for the Australian population – the recommended dietary intake of protein (19.9 kg per year) and the actual amount consumed (36.8 kg per year) with the data in Table 1. Just in the chicken and pig meat that omnivores eat, they indirectly consume 38 kg of plant protein a year. In other words, before they eat any plant material – cereals for breakfast, bread for lunch, vegetables with their meat or fruit as a snack, the average omnivore has already indirectly eaten double the recommended dietary intake of protein and a little more protein than they eat directly. Because eggs and milk supply about 12 kg of protein per year to both of our study groups – omnivores and lacto-ovo vegetarians, the latter need eat only 8 kg of plant protein to meet the annual RDI for protein, 13 kg to meet the typical annual protein intake of a typical vegetarian or 24 kg of plant protein to match the protein intake of an average Australian. To emphasise the point, before they eat any plant material, the average Australian omnivore will have indirectly consumed 14 kg more plant protein than will a lacto-ovo vegetarian eating a diet of similar protein content – 102 g of protein per day.

I think the consequences of this protein waste are obvious. Briefly, we grow more crops than we need, which necessitates farming more land, clearing more land, killing more sentient creatures, promoting fossil-fuel agriculture and causing far more damage to the environment than would occur if we changed our diet. The appropriate diet is one that's largely lacto-ovo vegetarian with animal products from grazing animals eating grass and pigs eating waste. In other words, a series of simple calculations refute Archer's argument. This should not surprise anyone with a rudimentary knowledge of ecology, who would know that eating at higher trophic levels elicits a loss of nutrients. For example, a cow that eats pasture (trophic level 1) has a trophic level of 2. The loss of energy between trophic levels is typically 80-97%. In a recent paper, Bonhommeau (2013) calculated the human trophic level for 176 countries for each year from 1961 to 2009 and found a median level of 2.21. Disturbingly, the trend towards eating more meat has increased this value by about 3% in 50 years. Commenting on the study in the prestigious journal Nature, Hannah Hoag states that it "reveals global shift towards animal-based diet — a bad omen for the environment" (Hoag 2013). The change – 3% in 50 years – may appear small, but over the same period the world's population more than doubled from 3 to 7 billion. Put simply, if short of food you would never feed your remaining grains and legumes to an animal and then eat the animal!

Now, I acknowledge that the focus of Professor Archer's article is "red meat". As I pointed out earlier in this article, Australian graziers produce much of this meat from animals eating pasture – grasses and other vegetation, the food that sheep and cattle evolved to eat. More importantly, pasture is food that humans cannot eat and thus it seems sensible for us to eat grazing animals. This suggests that Archer has the wrong target. It is not the vegetarians that have blood on their hands but the average Australian omnivore who, in 1976 ate 66 kg of beef and 21 kg of lamb in a year but now eats roughly half of that amount. In contrast, over this roughly 40 year period they have tripled their consumption of poultry to 43 kg per year and doubled their intake of pig meat to 25 kg.

Taking aim at vegetarians is not the sole domain of Professor Archer but a widespread practice especially in the tabloid newspapers. For instance, commenting on a study at Cranfield University commissioned by WWF, Fiona Macrae entitled her article in the Daily Mail "How being vegetarian does more harm to the environment than eating meat" (Macrae 2010). She then states, "Switching from British-bred beef and lamb to imported meat substitutes such as tofu increases the need for cultivated land". Nowhere did the article mention that in 2011 Britain imported 858,000 tonnes of soybeans and 2.29 million tonnes of soybean meal (HM Revenue & Customs (HMRC) Trade Statistics unit 2011). Let us assume that humans eat all of the soybeans in products such as tofu whereas British farmers feed all of the soybean meal to animals. Soybean meal contains 44% protein and thus 2.29 million tonnes could supply 18 kg of protein to each of the UK's 56 million people. This is most of the protein needs of the entire population! Vegetarians can also be targets in ways that are more esoteric. Barry Jones, in discussing the 2013 election, asserted "It would be just as odd to have a vegetarian as Minister for Agriculture, a pacifist as Minister for Defence or a climate change sceptic as Minister for Science" (Jones 2013). Actually, it would be perfectly sensible to have a vegetarian as Minister for Agriculture because they, at least, might acknowledge that plants and photosynthesis are the basis of life on earth and thus agriculture.

While I have touched on the obvious environmental issues involved in consuming livestock housed intensively and fed on crops, there are many and much wider issues stemming from our exuberance for farming animals. I will briefly discuss four of them – public health issues, phosphorus in the environment, the waste of wasted food and the link between animal agriculture, soybeans and climate change before returning to summarise why Archer's idea is so dangerous.

Public health

As our voracity for convenience foods increases so does our body mass. About 60 per cent of Australian adults and one in four children are overweight or obese, and the National Health and Medical Research Council predicts that this will rise to 83 per cent of men and 75 per cent of women by 2025. As in most of the developed world, much of the burden of disease in Australia is due to excessive consumption of energy-dense and relatively nutrient-poor foods that often goes hand in hand with an insufficient consumption of plant foods and a sedentary lifestyle (National Preventative Health Taskforce 2009). The seriousness of this rising obesity rate is that it is a common risk factor underlying the development of chronic diseases such as Type 2 diabetes, cardiovascular disease and some cancers. As with many diseases the burden often falls on individuals of lower socioeconomic status and the most disadvantaged areas (Burns and Inglis 2007). Any policy that reduces obesity may improve the health of Australians. It will also help protect an already overburdened health care system.

Large population studies suggest that one way we might tackle obesity is by eating a mainly vegetarian diet. Among these studies are the first and second Adventist Health Studies with 34,192 and 96,469 participants (Orlich et al. 2013; Snowdon 1988), which showed that both male and female vegetarians had lower body mass indices and lived longer than the non-vegetarian participants. In confirming these results, Key *et al.* (1999) combined data from five prospective studies – 76,172 men and women, to compare the death rates from common diseases of vegetarians with those of non-vegetarians living similar lifestyles. They stated that "compared with non-vegetarians, Western vegetarians have a lower mean BMI, a lower mean plasma total cholesterol concentration, and a lower mortality from ischemic heart disease."

The two faces of phosphorus

It is difficult to discuss the feeding of crops to livestock without considering the movement of phosphorus, an element crucial to the world's food supply system. Phosphorus is an essential nutrient for plant and animal growth. Unlike much of Europe, which faces the enormous challenge of phosphorus pollution, Australia – a continent of weathered soils, must also contend with a paucity of the element (State of the Environment 2011 Committee 2011). This is particularly true over much of the rangelands and especially in northern Australia (Jackson et al. 2012). Agricultural enterprises need to counter this problem because deficiencies of phosphorus often limit the growth and production of plants, which, in turn, limits animal production. Very low concentrations of available phosphorus in soils may lead to deficiencies in animals that manifest themselves as weak and distorted bones, poor growth, elevated mortality and botulism, through animals scavenging carcasses. To overcome soil deficiencies, farmers in more mesic regions of the country have applied soluble forms of phosphorus fertiliser since the 1920s. This practice allows them to cultivate crops and pasture species and to improve animal production but it may become extremely expensive because global supplies are diminishing. In contrast, the broad application of phosphorus is not feasible in the rangelands and instead some graziers feed phosphorus supplements to their stock. Cattle that are replete in phosphorus contain 7-8 g of phosphorus per kg of live weight. Thus, harvesting a 300 kg steer removes about 2 kg of phosphorus from the landscape. This may not seem like much but how does one replace it?

Phosphorus also has a dark side – surpluses of the element find their way into waterways through erosion, surface water runoff and leaching (Hooper et al. 2000) and cause tremendous damage. This is a particular problem whenever phosphorus can accumulate in small areas as often occurs with leaching from the intensive animal industries – poultry and pig farms, but especially from dairies. Although mentioning dairies here moves the argument away from lacto-ovo vegetarians, it serves to demonstrate the complex nature of the problem and the adverse effect that even dairy cattle may have on the environment. Presumably cattle in the rangelands, although stocked at low densities, are having a similar though more subtle effect on Australia's waterways.

The waste of Australia's wasted food

According to Foodwise (2013) Australians waste four million tonnes of edible food each year valued at $8 billion. If this food waste represents the entire Australian diet then it contains the annual nutritional needs of about one third of the Australian population (calculated from Australian women, aged 25-44 and Australian men aged 19-24, eating 1300 and 1680 g of food per day; ABS 1997). Assuming this waste is about 30% dry matter and contains 16 kJ of energy and 0.16 g of protein per g of dry matter, it would rear 3.8 million pigs to about 100 kg live-weight (and supply 40% of Australia's pig meat)! Obviously, it would preserve an enormous amount of crops for consumption somewhere by humans and reduce the indirect deaths of animals that occur when we grow crops. Feeding anything to pigs that has been exposed to meat or meat products – known as swill feeding, is forbidden in Australia, which makes the feeding of most food waste impossible. In contrast, Japan has various schemes for recycling the 20 million tons of food wasted each year (Maeda 2008).

Intensive animal production, soybeans and climate change

Agriculture requires land, water and energy to produce, process and distribute food. Where once agriculture relied almost entirely on solar energy to drive photosynthesis, it now relies almost entirely on past photosynthesis, in the form of fossil fuels. Consuming at higher trophic levels, as we do when we eat intensively farmed animals fed on crops that humans could consume directly, exacerbates the use of fossil fuels. Not only do we need them to produce the crops, but we use them also to transport the crops, to turn them into animal feedstuffs and to transport these feeds to animals. In addition, the poultry and pig industries use fossil fuels to control the climate in animal houses, to transport the animals to abattoirs, to kill and to process them and to store the final product. Moreover, we must import some of the crops used in animal feeds, the prime example being soybeans – a key source of amino acids for poultry and pigs. As Boucher *et al.* (2011) point out:

> *"Although most people think of soy in terms of traditional East Asian foods like soy sauce, soy milk, tofu, tempeh, and similar dishes, most soybeans are not consumed by people, but by livestock. Chickens, pigs, and cattle eat most of the global soy crop."*

While Australia grows about 38,000 tonnes per year, it imports over 500,000 tonnes per annum of soybean meal to supply the intensive livestock industries (M'Gee 2011). This is the equivalent of 9.4 kg of protein for everyone in Australia – now 23.3 million. Our tendency to eat more and more pig and poultry meat suggests that the demand for imported soybean will grow. Much of the world's soybeans come from Brazil, fractionally the second largest producer after the United States. Not surprisingly, along with the production of cattle, the growing of soybeans is responsible for much of the recent decimation of Amazonia, prompting the imposition of a moratorium on land-clearing for soybeans in 2006 (Boucher et al. 2011; Greenpeace 2006). Unfortunately, the situation is not so simple. First, the moratorium did not apply to the cerrado – the species-rich savannah. Secondly, farmers often grow soybeans on land degraded by cattle, and so often it is cattle farmers clearing the native forest (Barona et al. 2010). Karstensen et al. (2013) found that 30% of the carbon emissions associated with deforestation were exported from Brazil in the last decade. Of these 29% were due to soybean production and 71% to cattle ranching. Because Brazil exports most of its beef and soybeans, the authors concluded "that trade is a key driver of deforestation in Brazil".

The slaughter of animals – direct and indirect

The slaughter of animals, especially mice, is the centrepiece of Archer's argument and deserves a passing comment, although I saw it as bait and, like a wise fish, refused it! After all, how can someone so damning towards one feral species (cane toads; see Lewis 1988) be so passionate about another that episodically breaks into plagues? But let us laud mice. Comparing the indirect deaths that lacto-ovo vegetarians and omnivores are indirectly responsible for through cropping seems simple. After accounting for milk and eggs, if the average Australian omnivore consumes two-three times the plant protein of a lacto-ovo vegetarian then he is responsible for two-three times the number of animal deaths in the growing of those crops. Added to these deaths are those of all the animals that omnivores consume, starting with 27 chickens. On top of this are all those parent animals needed to produce the animals we eat, of which the fates of many are obscure – roosters, for instance. Of course, the calculation is not so simple and one needs to know far more about the origins of the plant products eaten by lacto-ovo vegetarians and omnivores to derive a better answer. But the message remains: the average Australian omnivore is responsible for far more deaths than is a lacto-ovo vegetarian. And vegetarians are not responsible for the animal welfare issues that continually arise through animal transportation and their slaughter.

Finally, the Archer paper raises the point of the singing behaviour in mice, urging us once more to emotionally attach ourselves to these animals. But what is so special about mice? The same argument applies to most animals. For example, young calves respond specifically to their mother's calls (e.g. Marchant-Forde et al. 2002).

In summary, in terms of the animal ethics argument, an important distinction is that the end point of the active choice of eating meat is the direct death of a sentient animal (the pig or cow) and, in some cases, the indirect death of other sentient animals (eg mice) through feed production. There will be indirect death associated with both diets but the preference of omnivores to eat animals raised on crops make them responsible for far more deaths than vegetarians. A vegetarian diet cuts out the direct death in this process. Arguing otherwise is a dangerous idea.

The final say

There is irrefutable evidence that those who eat a typical Australian diet have far more blood on their hands and are responsible for greater degradation of the environment than are those who choose a vegetarian diet. But perhaps the final say should go to philosopher Thích Nhất Hạnh:

"By eating meat we share the responsibility of climate change, the destruction of our forests, and the poisoning of our air and water. The simple act of becoming a vegetarian will make a difference in the health of our planet (Hạnh 2008)."

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